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No. 72—1917.

British Standards Institution
Report.

British Engineering Standards Committee.

Formed in 1901 by

THE INSTITUTION OF CIVIL ENGINEERS.
THE INSTITUTION OF MECHANICAL ENGINEERS.
THE INSTITUTION OF NAVAL ARCHITECTS.
THE IRON AND STEEL INSTITUTE.
THE INSTITUTION OF ELECTRICAL ENGINEERS.

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BRITISH

STANDARDISATION RULES

FOR

ELECTRICAL MACHINERY

(EXCLUDING MOTORS FOR TRACTION PURPOSES).

REVISED SEPTEMBER, 1917.

LONDON:
PUBLISHED FOR THE COMMITTEE BY CROSBY LOCKWOOD & SON,
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The following are lists of Members of the Sectional Electrical Committee and of the Sub-Committee on Standardisation Rules for Electrical Machinery.

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* President, British National Committee. † Hon. Sec. British National Committee.
‡ Also nominated by the Institution of Electrical Engineers.

PREFACE TO FIRST EDITION.

The Sub-Committee on Standardisation Rules for Electrical Machinery was appointed at a meeting of the Sectional Electrical Committee held on 12th June, 1914, which appointment was confirmed by the Main Committee on 16th July, 1914.

The representative character of the Sub-Committee, including, as it does, representatives not only of the large spending Departments of the Government and of the Municipalities, but also eminent Consulting Engineers, together with representatives of the British Manufacturers of Electrical Machinery as a whole, has enabled the Committee to gather the collective views of the various interests concerned in a manner which, hitherto, has not been possible.

The Rules have been based on the Limiting Temperatures for insulating materials agreed to at the last Plenary Meeting of the International Electrotechnical Commission, held in Berlin in 1913. Considerable advantage has accrued through the co-operation of the American Standards Committee in this work, and a Conference extending over several days, which was held in London in March, 1915, at which Mr. H. M. Hobart and Mr. C. E. Skinner were the Official Representatives nominated by the American Institute of Electrical Engineers, has gone far towards bringing about agreement on all essential details. At this Conference, the Canadian National Committee of the I.E.C. was also officially represented by Mr. A. P. Trotter.

The Committee feel confident that the wide adoption of these Standardisation Rules will materially benefit the industry of this country.

This Report was adopted by the Sectional Electrical Committee at their meeting on 16th July, 1915.

This Report was approved by the Main Committee at their meeting on 22nd July, 1915.

R. T. GLAZEBROOK,

Chairman of Sub-Committee on Standardisation Rules for Electrical Machinery.

PREFACE TO FIRST REVISION.

In March, 1916, the American Institute of Electrical Engineers invited the Committee to be represented at meetings of their Standards Committee to be held at New York and Atlantic City. In view of the advantage which already had accrued from co-operation with the American Committee, the Main Committee accepted this cordial invitation and instructed Mr. le Maistre to attend the meetings. Various points in regard to the British and American Rules were discussed, with the result that a number of suggestions put forward and mutually agreed to have been taken account of in the present revision. The text has been rearranged and an introduction included, which it is believed will facilitate and promote the general use of the Rules.

The Standardisation Rules for Electrical Machinery in their present form were approved by the Sectional Electrical Committee at their meeting on 13th July, 1917.

The report in its present form was approved by the Main Committee at their meeting on 26th July, 1917.

R. T. GLAZEBROOK,

Chairman of Sub-Committee on Standardisation Rules for Electrical Machinery.

NOTE.—*The Committee desire to call attention to the fact that these Standardisation Rules are intended to include the technical provisions necessary for the supply of material herein referred to, but do not purport to comprise all the necessary provisions of a contract.*

BRITISH STANDARDISATION RULES FOR ELECTRICAL MACHINERY

(EXCLUDING MOTORS FOR TRACTION PURPOSES).

[REVISED SEPTEMBER, 1917.]

INTRODUCTION.

The object of these Rules is to define the conditions which characterise British Standard Electrical Machinery, including transformers (but excluding traction motors, for which special rules will be issued), and to provide the Purchaser and the Manufacturer with a general specification applicable to the great majority of electrical machines.

The information which should be forwarded with an enquiry or an order for an electrical machine is set out in detail in Section I. With these particulars* before them, manufacturers will have sufficient information to be able to submit tenders and to supply suitable machines with a minimum of correspondence.

Definitions of the technical terms used in the Rules are included in Section II., and in particular the term "Rating" or "Rated Output" is exactly defined. The Definition of Rating or Rated Output was arrived at in close co-operation with the American Institute of Electrical Engineers, and was finally decided upon at a Conference of the American, British and Canadian representatives held in London in 1915.

This British Standard Rating provides an equitable basis of comparison for electrical machinery, and, although constituting a departure from the practice of the past, is in conformity with the considered views of the International Electrotechnical Commission in regard to the exclusion of overloads. At the same time this does not imply a reduction in the mechanical or commutating properties of the machine, excess load and commutating tests being provided for in the Rules. A note in regard to this "Single Rating" appears in Section V., Clause 37.

*Details of special mechanical requirements, if such are necessary, should also be furnished (type of gearing, size of pulley, slide rails, etc.)

The use of the correct name and type of machine is clearly of great importance, particularly when telegraphing instructions or enquiries, and this information is given in Section IV.

The limits of altitude and of air temperature under which British Standard Machines can be used are given in Sections VI. and VII., and most of the industrial centres of the world come within these limits. Machinery for use at high altitudes, or in climates having exceptionally low or high temperature not dealt with in the Rules must be ordered specially.

Enquiries based on these Rules will enable a Purchaser to compare, on a common basis, tenders received from various manufacturers, and, as a general rule, when sending an enquiry or order for electrical machinery, it will only be necessary to give the information specified in Section I., stating at the same time that the machinery is to comply with the requirements of the British Standardisation Rules, Report No. 72–1917.

I.

INFORMATION TO BE GIVEN WITH ENQUIRY AND WHEN ORDERING ELECTRICAL MACHINES.

(Instructions as to information in regard to Mechanical Details are so far not included.)

For the purposes of these Rules the term "machine" implies a generator, motor or transformer. (*See* Clause 8.)

Special attention is directed to the following methods for stating the output of electrical machinery.

Continuous-current Generators.—The output shall be expressed in kilowatts (KW.) available at the terminals.

Alternators.—The output (apparent) shall be expressed in kilovolt-amperes (KVA.) available at the terminals.

Motors.—The mechanical output shall be expressed in horse power (H.P.) and in kilowatts (KW.) available at the shaft.

Transformers.—The output (apparent) shall be expressed in kilovolt-amperes (KVA.) available at the secondary terminals.

General Information to be given with Enquiry or Order.

1. When enquiring for or ordering an electrical machine the following particulars should be supplied:—

(*a*) The class of rating (*see* Section V.).

(*b*) The type of machine (*see* Section IV.)

(*c*) If it exceeds 40° C. the maximum temperature of the cooling air in the place in which the machine is intended to work in ordinary service (*see* Section VI.).

(*d*) If it exceeds 3,300 feet (1,000 metres approximately), the altitude of the place in which the machine is intended to work in ordinary service (*see* Clause 40).

(*e*) If a machine is required to operate between various limits of pressure, current, frequency or speed, the corresponding values of the pressure, current, frequency and speed respectively.

(*f*) The additional information required by the following clauses (2 to 7).

Additional Information with Enquiry or Order for Continuous-current Generator.

2. When enquiring for or ordering a continuous-current generator the following particulars should be supplied, in addition to the requirements of Clause 1.

Electrical output at the terminals, in kilowatts (KW.), with a statement as to the class of rating.

Pressure between the terminals, in volts.

Current, in amperes.

Speed, in revolutions per minute.

Method of excitation, whether shunt, series or compound.

Additional Information with Enquiry or Order for Continuous-current Motor.

3. When enquiring for or ordering a continuous-current motor, the following particulars should be supplied in addition to the requirements of Clause 1.

Mechanical output at the shaft, in H.P. (or KW.), with a statement as to the class of rating.

Pressure between terminals, in volts.

Speed at rated output, approximate, in revolutions per minute (*see* Clause 101).

Method of excitation, whether shunt, series or compound.

Additional Information with Enquiry or Order for Alternating-current Transformer.

4. When enquiring for or ordering an alternating-current transformer, the following particulars should be supplied in addition to the requirements of Clause 1.

Frequency in periods per second.

Number of phases.

Electrical output in KVA., with a statement as to the class of rating.

Pressure between terminals, in volts, at no load.

Power factor at full load of the circuit to be supplied. (If the power factor is not specified it shall be taken as 0·8.)

For transformers required to work in parallel:
The pressure, primary current and power factor, all on short-circuit, shall also be stated.

For three-phase transformers:
The method of connection shall also be indicated in accordance with the vector diagrams (*see* Section XIX.).

Any special requirements as to the accessibility of neutral points and special tapping points shall be specified.

The primary terminals of a transformer, for whatever purpose (step-up or step-down), are those on the input side and the secondary terminals are those on the output side. (*See* Clauses 16 and 17.)

Additional Information with Enquiry or Order for Synchronous Alternator.

5. When enquiring for or ordering a single-phase or poly-phase synchronous alternator the following particulars should be supplied in addition to the requirements of Clause 1.

Frequency, in periods per second.

Number of phases.

Electrical output, in KVA., with a statement as to the class of rating.

Pressure between terminals, in volts, corresponding to the rated output.

Power factor. If the power factor is not specified it shall be taken as 0·8.

Current, in amperes.

Speed, in revolutions per minute.

Excitation pressure, in volts, if the alternator is not provided with a special exciter.

PRIME MOVERS.—The most economical output of the turbine (*i.e.*, the output at which it attains its maximum steam economy) should not correspond with the generator rating in KW. except under

special circumstances. In general, it will be found preferable, when ordering a combined set, to specify that the most economical output of the turbine shall be equal to 80 per cent. of the KW. rating of the generator as defined in these Rules, *i.e., equal to* 80 *per cent. of the maximum continuous output of the generator in KW.* (*see* Clause 37). The average output of the alternator is usually something between three-quarters of the rated output and the rated output, and the average output of the combined set should clearly be the most economical output for the prime mover.

When the power factor of the generator is not specified it shall be taken as 0·8.

It should be further stated that, for mechanical reasons, the steam inlets should be capable, by means of bye-passes or otherwise, of dealing continuously with outputs 12 per cent. in excess of the rated output, which is 40 per cent. in excess of the economical output as defined above.*

Additional Information with Enquiry or Order for Synchronous Motor.

6. When enquiring for or ordering a single-phase or polyphase synchronous motor the following particulars should be supplied, in addition to the requirements of Clause 1.

Frequency, in periods per second.

Number of phases.

Mechanical output at the shaft, in H.P. (or KW.), with a statement as to the class of rating.

Pressure, in volts, of the supply available.

Speed, in revolutions per minute.

Method of starting to be employed and the source of the power available for this purpose.

Power Factor at which rated mechanical output is required. Unless otherwise specified, it shall be understood that the motor is capable of giving its rated mechanical output at unity power factor.

The wattless leading current component shall be stated if the motor is required to act as a device for improving the power factor.

Excitation pressure, in volts, if the motor is not provided with a special exciter.

Additional Information with Enquiry or Order for an Induction Motor.

7. When enquiring for or ordering a single-phase or polyphase induction motor the following particulars should be supplied in addition to the requirements of Clause 1.

Frequency, in periods per second.

Number of phases.

* This note will be reconsidered after the Sub-Committee on Prime Movers for Electrical Plant has issued its Report.

Mechanical output at the shaft, in H.P. or (KW.), with a statement as to the class of rating.

Pressure between terminals, in volts.

Speed, in revolutions per minute, approximate, at the rated output.

Rotor, whether to have slip rings or to be squirrel cage (*i.e.*, permanently short circuited.)

Unless otherwise specified it is assumed that the stator receives the supply current.

Method of starting to be employed.

Starting torque in terms of the rated load torque and the corresponding starting current which can be taken from the supply with the starting accessories connected.

II.

DEFINITIONS.

Definition of Machine.

8. For the purposes of these Rules the term "machine" implies a generator, motor or transformer.

Definition of Rating or Rated Output.

9. The Rating of an electrical machine is the output marked on the rating plate and shall be the maximum load which can be taken from the machine under the prescribed conditions of test. This is called the Rated Output.

Loads applied solely for the purpose of mechanical, commutation or other specified tests may exceed the "maximum load" (*see* Note to Clause 56).

Definition of British Standard Rating or Rated Output.

10. If the prescribed conditions of test are those of the British Standardisation Rules, the rating of the machine is the British Standard Rating, or the British Standard Rated Output. A machine so rated will bear a distinctive sign upon its rating plate (*see* Clause 103).

Definition of Continuous Rating.

11. Continuous Rating is the output at which a machine can work continuously for an unlimited period and comply with these rules (*see* Clause 37).

Definition of Short-time Rating.

12. Short-time Rating is the output at which a machine can work for a limited period (to be specified in writing in each case) and comply with these rules (*see* Clause 38).

Definition of Observable Temperatures.

13. Observable Temperatures are temperatures measured on accessible surfaces of the completed machine by thermometers, resistance thermometers or thermo-couples (such temperatures are referred to as thermometer temperatures), and also those temperatures calculated from the value of increase of resistance of the machine windings.

The expression "by the resistance method" or "by resistance" may be used instead of "from the value of increase of resistance of the machine windings."

Definition of Maximum Observable Temperature.

14. The Maximum Observable Temperature is the highest of the observable temperatures.

Definition of Embedded Temperature Detectors.

15. Embedded Temperature Detectors are resistance thermometers or thermo-couples built into the machine during construction at points which are inaccessible when the machine is completed.

Definition of Primary Terminals of a Transformer.

16. The Primary Terminals of a transformer, for whatever purpose (step-up or step-down), are those on the input side.

Definition of Secondary Terminals of a Transformer.

17. The Secondary Terminals of a transformer, for whatever purpose (step-up or step-down), are those on the output side.

Definition of Regulation of an Alternator.

18. The normal inherent regulation of an alternator is the rise in pressure from rated output, at the specified power factor and rated pressure, to no-load, with constant speed and excitation; the rise in pressure is the difference between the pressure at rated output and at no-load stated as a percentage of the rated pressure.

Definition of Regulation of a Transformer.

19. The normal inherent regulation of a transformer is the rise in secondary pressure from rated output, at the specified power factor and rated secondary pressure, to no-load, with constant primary pressure; the rise in pressure is the difference between the pressure at rated output and at no-load stated as a percentage of the full load pressure.

Definition of Tolerance.

20. A Tolerance, for the purposes of these Rules, is the amount of permissible difference between the results observed on test and the results required by these rules.

Definition of Horse-Power.

21. One Horse-power, for the purposes of these Rules, shall be taken as equivalent to 746·0 watts.

III.

PRESSURES, FREQUENCY, PHASES AND WAVE FORM.

Pressures for Motors.

22. The Standard Pressures for Motors are :—

Continuous Current Volts.	Alternating Current Volts.
110	200
220	400
440	500
460	
500	

Frequency for Alternating Current Machines.

23. The Standard Frequency for alternating current machines shall be 50 periods per second.

Number of Phases for Alternating Current Machines.

24. The Standard number of phases for alternating current machines shall be three.

Wave Form of Alternators.

25. The wave form of an alternator on open circuit shall approximate to a sine wave. In cases where the wave form is stated to be of importance at the time of ordering the machine the maximum deviation of the actual wave from the equivalent sine wave when superimposed on it so as to give the least difference shall not exceed 10 per cent. of the maximum ordinate of the sine wave ; the equivalent sine wave being one having the same R.M.S. (root-mean-square) value and the same wave length.

Standard Machines for Non-Standard Frequencies and Phases.

26. Machines, other than two-phase machines, for use on systems employing frequencies or phases other than the Standard, but which comply in all other respects with the requirements of these rules, shall be British Standard Machines, and the frequency and number of phases for which they are designed shall be stated on the rating plate (*see* Section XVIII.).

IV.

TYPES OF MACHINES.

GENERATORS AND MOTORS.

Open Pedestal Machine.

27. An Open Pedestal Machine is one having pedestal bearings, and in which there is no restriction to ventilation other than that necessitated by good mechanical construction.

Open End-Bracket Machine.

28. An Open End-Bracket Machine is one having end bracket bearings, and in which there is no restriction to ventilation other than that necessitated by good mechanical construction.

Protected Machine.

29. A Protected Machine is one having end bracket bearings, and in which the internal rotating parts and live parts are protected mechanically from accidental or careless contact while ventilation is not materially obstructed.

Enclosed Ventilated Machine.

30. An Enclosed-Ventilated Machine is one in which the ventilating openings in the frame are protected with wire screen, expanded metal or other suitable perforated covers having apertures not exceeding $\frac{1}{2}$ sq. in. (3·2 sq. cm.) in area, but not less than $\frac{1}{50}$ sq. in. (0·13 sq. cm.) in area.

Machines having openings smaller than $\frac{1}{50}$ sq. in. (0·13 sq. cm.) in area shall comply with these Rules when the machine is tested with the openings closed, as such openings frequently become clogged in actual service.

Totally-Enclosed Machine.

31. A Totally-Enclosed Machine is one in which the enclosing case and bearings are dust-proof, and which does not allow a circulation of air between the inside and outside of the case.

Pipe-Ventilated Machine.

32. A Pipe-Ventilated Machine is an enclosed machine in which the frame is so arranged that the ventilating air may be conveyed to it through a pipe attached to the frame, the ventilation being maintained by the fanning action produced by the machine itself or by an internal fan.

If the heated air expelled from the machine is conveyed away through a second pipe attached to the machine, this should be specially stated.

Forced-Draught Machine.

33. A Forced-Draught Machine is an enclosed machine in which the ventilating air supply is maintained by an independent fan external to the machine itself.

Drip-Proof Machine.

34. A Drip-Proof Machine is one having a frame provided with openings for ventilation so protected as to exclude falling moisture or dirt.

Flame-Proof Machine.

35. A Flame-Proof Machine is one in which the enclosing case can withstand, without injury, any explosion of gas that may occur within it, and will not transmit the explosion to any inflammable gas outside it.

A machine in which the slip rings and brushes alone are enclosed in a flame-proof case is not called a flame-proof machine. Such a machine should be referred to as one with a "flame-proof slip-ring enclosure."

V.

CLASSES OF RATING.

Classes of Rating.

36. Two Classes of Rating are recognised by these Rules:—

(*a*) Continuous Rating—For machines intended for continuous service. (For definition *see* Clause 11.)

(*b*) Short-time Rating—For machines intended for intermittent service. (For definition *see* Clause 12.)

When a machine will be required to work continuously with loads varying between very wide limits and the actual cycle of duty is specified, the machine may be given a Duty-cycle Rating, this being the continuous rating which is the thermal equivalent of the cycle of duty specified. A machine with duty-cycle rating shall, in addition, be capable of withstanding a momentary load corresponding to the highest peak of load occurring in the cycle of duty specified (*see* Note to Clause 80).

Standard for Continuous Rating.

37. The British Standard for Continuous Rating is the output at which a machine can work for an unlimited period and comply with these rules.

It has been the general practice in the past to specify the output of Electrical Machinery intended for continuous service on the basis of a normal continuous rating with a definite over-load allowed for a limited period. The British Standard Rating, as defined in these rules, includes the equivalent of the previous over-load, and, therefore, only such momentary excess loads are recognised as are provided for in these rules.

The design of the machine should preferably be such that its point of maximum efficiency occurs at about 80% of the rated power output.

Standards for Short-time Rating.

38. For general purposes two Standards for Short-time Rating are recognised:—

(*a*) One hour Rating. The output at which a machine can work for one hour and comply with these rules.

(*b*) One half-hour Rating. The output at which a machine can work for one half-hour and comply with these rules.

Class where Rating is not Specified.

39. When the class of rating is not specified it shall be understood that the machine is intended for continuous service.

Rating where Altitude is not Specified.

40. When the altitude is not specified it shall be understood that the machine is intended for altitudes not exceeding 3,300 feet (1,000 metres approximately) above sea level.

Rating for Generator, Rotary Converter, or Transformer with two Limits of Pressure.

41. A generator, rotary converter, or transformer intended to operate between two limits of rated pressure shall have its rated current determined at the higher pressure unless otherwise specified.

Rating for Motor with two or more Fixed Speeds (Multi-Speed Motor).

42. A motor with two or more fixed speeds shall have a definite rating for each speed.

Rating for Motor with Variable Speed.

43. A variable speed motor shall have a definite rating for each of the limiting speeds specified.

VI.

COOLING AIR TEMPERATURE.

The life of a machine depends in great measure on the maximum temperature to which the insulation is exposed. This maximum temperature depends on the output the machine is giving and on the temperature of the air or other cooling medium. For the purpose of establishing the permissible temperature rise in a standard machine, so as never to exceed the limits permissible for total temperature, it is necessary to consider not the *average* but the *maximum* temperature to which the cooling air may rise in service. Numerous records have been examined and 40° C. has been selected as the most suitable value to be adopted as the maximum temperature of the cooling air for temperate climates. Accordingly, the limits of observable temperature rise given in Clause 46 have been obtained by subtracting in each case 40° C. from the limits of observable temperature. Special rules will be necessary in cases where the cooling air temperature exceeds 40° C.

Maximum Cooling Air Temperature.

44. The maximum cooling air temperature to which these Rules apply is 40° C. and the limits of temperature rise given

in these rules apply to all temperatures of cooling air not exceeding 40° C., but not to temperatures of cooling air exceeding 40° C. (*see* Clauses 50 and 56).

VII.

OBSERVABLE TEMPERATURES.

Thermal Conditions for Rating.

45. The observable temperature (for Definition *see* Clause 13) and the observable temperature rise are the thermal quantities which determine the British Standard Rating of a machine.

The average temperature of the windings of a machine can be determined by calculation based on the measurement of their electrical resistance, and the temperature at a point on the winding can be measured provided a thermometer (*see* Clause 13) can be applied to the spot and protected satisfactorily from external influences, such as probable air-currents. The temperatures determined by measurement of the resistance and by use of a thermometer are spoken of as the "observable temperatures" of the machine.

Limits of Observable Temperature.

46. Rotating machines wound for pressures not exceeding 5,000* volts, and transformers for any pressure, working under the conditions of their British Standard Rating, shall not exceed in any of their parts the limits of observable temperature and temperature rise given in the following table and subject to the conditions specified in Sections VIII. and IX.

Column 4 gives the limits of observable temperature rise. Column 5 gives the limits of observable temperature. The figures in Column 4 are found by subtracting from those in Column 5, 40° C., the maximum temperature of cooling air to which the temperature rises given in these rules apply.

* For generators or motors for pressures exceeding 5,000 volts, *see* Clause 48.

No. 46—continued.

1	2	3	4	5	6
Item.	Class (1)	Material or Part.	Limits of Observable Temperature Rise.	Limits of Observable Temperature.	Methods of Measuring Temperature Rise. See Clause:—
			C	°C	
		STATIONARY AND ROTATING C.C. FIELD COILS.			
1.	A.	Cotton, silk, paper and similar materials when impregnated (2)	55	95	68 & 69
2.	A.	Enamelled wire	55	95	
3.	B.	Asbestos, mica and similar materials	75	115	
		ROTATING ARMATURES WITH COMMUTATORS.			
4.	A.	Cotton, silk, paper and similar materials when impregnated (2)	50	90	68
5.	A.	Enamelled wire	50	90	
6.	B.	Asbestos, mica and similar materials	70	110	
		A.C. WINDINGS IN SLOTS.			
7.	A.	Cotton, silk, paper and similar materials when impregnated (2)	55	95	69 & 70
8.	A.	Enamelled wire	55	95	
9.	B.	Asbestos, mica and similar materials	75	115	
		SHORT-CIRCUITED WINDINGS.			
10.		Insulated	60	100	72
11.		Uninsulated	*see* Clause 52		
		COMMUTATORS.			
12.		For C.C. and A.C. Machines ...	50	90	72
13.		**SLIP-RINGS.**	50	90	72
		AIR-COOLED TRANSFORMERS.			
14.	A.	Cotton, silk, paper and similar materials when impregnated (2)	55	95	71
15.	A.	Enamelled wire	55	95	
16.	B.	Asbestos, mica and similar materials	75	115	
		OIL-COOLED TRANSFORMERS.			
17.		Insulating materials, immersed in oil	55	95 (3)	71
18.		Oil	50	90 (3)	
19.		**IRON CORES.**	*see* Clauses 52 and 53		72

(1) For the class of insulating material *see* table in Appendix I.

(2) For non-impregnated material *see* Clause 47.

(3) Provisionally adopted pending the Report of the Research Committee of the Institution of Electrical Engineers.

Temperature Limits for Non-Impregnated Materials.

47. For cotton, silk, paper and similar materials when neither impregnated nor immersed in oil, the limits of observable temperature and temperature rise shall be 10° C. below the limits fixed for these materials when impregnated, as given in Clause 46.

Temperature Limits for Generators or Motors for pressure exceeding 5,000 volts.

48. For a generator or motor wound for a pressure exceeding 5,000 volts the limits of observable temperature given in Clause 46 shall be reduced by 1½° C. for each 1,000 volts or part thereof by which the rated pressure exceeds 5,000 volts and subject to the conditions specified in Sections VIII. and IX.

Temperature Limits for Transformer for any Pressure.

49. For a transformer wound for any pressure the limits of observable temperature and temperature rise given in Clause 46 shall apply, subject to the conditions specified in Sections VIII. and IX.

Temperature Limits in Service.

50. Whatever may be the temperature of the cooling air when the machine is in service, the limits of the maximum observable temperature and temperature rise specified for the test and given in Clauses 46 and 48 should not be exceeded in service.

Temperature Limits for High Altitudes.

51. For a machine intended for service at an altitude above 3,300 feet (1,000 metres approximately), the observable temperature rise, if tested near sea-level, shall be reduced 2½ per cent. for each 1,000 feet above sea-level at which the machine is intended to work in service. The correction shall not be applied for altitudes below 3,300 feet.

Temperature Limits for Iron Core and other Uninsulated Parts.

52. The maximum observable temperature and temperature rise of the iron core and other parts of the machine in contact with or adjacent to the windings shall not exceed the limits permitted for the insulating material on those windings as shown in the table Clause 46. The temperature of uninsulated parts (such as uninsulated squirrel cage windings) shall in no case reach such a value that there is risk of injury to any insulating material on adjacent parts.

Temperature Limits for Transformer Core, etc., Immersed in Oil.

53. The maximum observable temperature and temperature rise of a transformer core or similar apparatus immersed in oil, even if not in contact with the windings, shall not exceed the limits permitted for the windings in oil.

Temperature Limits for Insulation made up of Different Materials.

54. When the insulation is made up of different materials the lowest temperature allowed for any of the different insulating materials employed is to be adopted as the limiting temperature, excepting in cases where it can be shown that the temperature and temperature rise of each component part are not in excess of the limits allowed for the materials forming that part.

Material employed in small quantities in the construction and not relied upon continuously as a support for the insulating material is not regarded as part of the insulation under this rule.

Temperature Limits for Insulation on Various Parts of one Winding.

55. When different insulating materials are used on various parts of one winding (for instance, in the slot and on the end-windings) the temperature limit given for each material is permissible for the part where that material is used.

VIII.

TEMPERATURE TESTS.

Output of Machine during Temperature Test.

56. The temperature test of a machine shall be carried out at its rated output and at any convenient air temperature not exceeding 40° C. (*see* Clause 82).

If it is desired to reduce the time needed to attain the final temperature it is permissible to operate the machine at an increased pressure or current, or both, during the early part of the run, the load being afterwards reduced to rated conditions and so maintained for a period sufficient to ascertain that the temperature rise corresponding to the rated output has become practically constant.

Correction of Observed Temperature Rise for Variations in Cooling Air Temperature.

57. No correction shall be made to the observed temperature rise in those cases where the temperature of the cooling air during the test is different from that in service, except in the special case dealt with in Clause 58.

Tests on actual machines have shown that the correction is sometimes positive and sometimes negative, and is in any case so small that it may be neglected.

Correction of Observed Temperature Rise for Air-Blast Transformer.

58. In the case of a transformer cooled by an air-blast, the limits of temperature rise permitted by Section VII. shall be reduced by 1 per cent. for each 2° C. that the temperature of the air entering the transformer is below 40° C.

Duration of Temperature Test for Machine with Continuous Rating.

59. The temperature test for a machine for continuous service shall be continued until sufficient evidence is available to show that the maximum temperature and temperature rise would not exceed the requirements of the rules if the test were prolonged until a steady final temperature were reached (*see* Clause 63).

Duration of Temperature Test for Machine with Short-time Rating.

60. The duration of the temperature test for a machine for intermittent service shall be the time required by the rating (*see* Clause 64).

Duration of Temperature Test for Machine having more than One Rating.

61. The duration of the temperature test for a machine with more than one rating shall be the time required by that rating which produces the greatest temperature rise. In cases where this cannot be determined beforehand the machine shall be tested separately under each rating.

IX.

MEASUREMENT OF THE OBSERVABLE TEMPERATURE.

Time at which Temperatures are to be taken.

62. The temperature of a machine shall, whenever possible, be taken during working as well as after stopping the machine ; the highest figure thus obtained shall be adopted as the maximum observable temperature (for definition *see* Clauses 13 and 14). When successive measurements show increasing temperatures after shut-down the highest value shall be taken.

In the case of rotating parts, if the interval between the instant of shut-down and the time of making the temperature measurement is such that the temperature has fallen appreciably, suitable corrections shall be applied so as to obtain as nearly as practicable the temperature at the instant of shut-down.

Initial Temperature of Machine with Continuous Rating.

63. The temperature test (*see* Section VIII.) for a machine for continuous service shall commence when the highest of the observable temperatures of the windings is not very different from that of the cooling air.

Initial Temperature of Machine with Short-time Rating.

64. The temperature test (*see* Section VIII.) for a machine for intermittent service shall commence when the highest of the observable temperatures of the windings is the same as that of the cooling air.

Method of Measuring Observable Temperature by Thermometer.

65. When the temperature is to be measured by thermometer, several thermometers shall be applied to the hottest accessible stationary parts of the machine during the test period and other thermometers to the rotating parts as soon as the machine is stopped after the test. In all cases the bulbs of the thermometers shall be suitably protected.

In places where there is any varying or moving magnetic field, alcohol thermometers should be used in preference to mercury thermometers, as the latter are unreliable under these conditions.

Method of Measuring Observable Temperature by Resistance.

66. When the temperature is to be measured by resistance (*see* Note to Clause 13), the highest of the observable temperatures of the winding measured by thermometer previous to the test shall not be very different from that of the cooling medium. The initial resistance of the winding and the temperature of the winding shall be measured at the same time. The final temperature of the winding shall be calculated* from the ratio of the resistances hot and cold, and the initial temperature (by thermometer) of the winding itself. Thermometer measurements shall also be made to ascertain if there is any higher observable temperature, and if such is found it shall be adopted as the maximum observable temperature.

Alternative Method of Measuring Observable Temperature by Thermometer.

67. The use of thermometers alone is permissible in certain specific cases (*see* Clauses 68, 69 and 70) even when the resistance method (*see* Clause 66) of measuring temperature is practicable.

In such cases the permissible temperature limits for the thermometer measurements shall be 5° C. less than those allowed for measurements by resistance.

Measurement of Observable Temperature of Continuous Current Generator or Motor.

68. The temperature of shunt or separately excited field coils shall be ascertained by the resistance method (*see* Clause 66), but

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* If R_2 = the resistance hot and R_1 = the resistance cold and t_0 = the initial temperature, the final temperature of the winding is given by the formula, final temperature $= \frac{(R_2/R_1 - 1)}{\text{temp. coeff.}} + t_0$. For temperature coefficient *see* Clause 77.

the alternative method by thermometer (*see* Clause 67) may be used provided the maker can, if required, produce evidence that if the resistance method had been employed, the limits of observable temperature rise (*see* Section VII.) would not have been exceeded.

The temperature of the armature, commutator, series field coils, compensating and commutating coils shall be ascertained by thermometer (*see* Clause 65).

Measurement of Observable Temperature of Synchronous Motor or Alternator.

69. The temperature of the field windings shall always be ascertained by the resistance method (*see* Clause 66).

The temperature of the stator (the "induced") winding shall whenever practicable, be ascertained by resistance (*see* Clause 66), When the resistance method is inapplicable the temperature shall be ascertained by thermometer (*see* Clause 65).

In the case of the stator winding (but not of the field winding) of a machine for less than 5,000 volts, it is permissible to employ the alternative method by thermometer (*see* Clause 67) even when the resistance method would be practicable.

Measurement of Observable Temperature of Induction Motor or Alternator without Commutator.

70. The temperature of the stator and rotor shall be ascertained, whenever practicable, by the resistance method (*see* Clause 66). When the resistance method is inapplicable the temperature shall be ascertained by thermometer (*see* Clause 65).

In the case of a machine wound for less than 5,000 volts, it is permissible to employ the alternative method by thermometer (*see* Clause 67) even when the resistance method would be practicable.

Measurement of Observable Temperature of Transformer.

71. The temperature of the windings shall be ascertained by the resistance method (*see* Clause 66). The temperature of the oil shall be ascertained by thermometer (*see* Clause 65).

Measurement of Observable Temperature of Commutator, Short-Circuited Windings and other parts of a Machine.

72. The temperature of commutators, permanently short-circuited windings and of parts other than the windings shall be measured by thermometer (*see* Clause 65).

X.

MEASUREMENT OF INTERNAL TEMPERATURES BY EMBEDDED TEMPERATURE DETECTORS.

A closer approximation to the Highest Internal Temperatures can be obtained by the introduction of thermo-couples or resistance thermometers—embedded temperature detectors—during the construction of the machine; and their use leads to a more accurate knowledge of the temperatures at those points. Such temperatures are in many cases higher than those measured by thermometers applied to the surface or by the method of increase of resistance of the winding. When the internal temperature is to be measured by embedded temperature detectors, a liberal number of these devices should be employed, and all reasonable efforts consistent with safety should be made to place them at the various points where the highest temperatures are likely to occur.

Embedded Temperature Detectors.

73. When so specified with the enquiry, embedded temperature detectors shall be employed in the case of a machine of over 3,000 kilowatts if wound for a rated pressure exceeding 3,300 volts, but the machine shall be considered to comply with these rules as regards temperature, provided the machine fulfils the requirements of Section VII. (*see* Appendices I. and II.).

XI.

MEASUREMENT OF THE TEMPERATURE OF THE COOLING AIR.

Position of Thermometers for measuring Cooling Air Temperature.

74. The temperature of the cooling air shall be measured by means of several thermometers placed at different points around and half-way up the machine at a distance of from three to six feet. These thermometers shall be so placed as to indicate the temperature of the current of air flowing towards the machine, and shall be protected from heat radiation and stray draughts.

Position of Thermometers for measuring Cooling Air Temperature for Pipe-Ventilated and Forced-Draught Machines.

75. The temperature of the cooling air for a Pipe-Ventilated or Forced-Draught machine shall be measured by a thermometer placed in the current of incoming air near its entrance into the machine.

Value of Cooling Air Temperature during Test.

76. The value to be adopted for the temperature of the cooling air during the temperature test shall be the mean of the readings of the thermometers, placed as required by Clause 74, taken at equal intervals of time during the last quarter of the duration of the test.

In order to avoid errors due to the time lag between the temperature of a large machine and the variations in the temperature of the cooling air, all reasonable precautions shall be taken to reduce these variations and the errors arising therefrom.

XII.

TEMPERATURE COEFFICIENT OF CHANGE OF RESISTANCE OF COPPER.

Temperature Coefficient of Copper.

77. The temperature coefficient of the change of resistance of copper shall be deduced from the formula $1/(234{\cdot}5 + t_0)$ where "t_0" is the initial temperature of the winding. For example, at an initial temperature of 30° C. the temperature coefficient of increase in resistance per degree Centigrade rise is $1/(234{\cdot}5 + 30) = {\cdot}00378$. The values in the Table have been deduced from this formula.

Temperature of the winding in degrees Centigrade at which the initial resistance is measured.	Copper—increase in resistance per Ohm., per degree Centigrade.
0	0·00427
5	0·00418
10	0·00409
15	0·00401
20	0·00393
25	0·00385
30	0·00378
35	0·00371
40	0·00364

XIII.

EXCESS CURRENT AND TORQUE TESTS.

Application of Excess Current and Torque Tests.

78. These tests, if called for, shall be carried out at the maker's works, unless otherwise specified, and shall be applied to

a new and completed machine in normal working condition with all its parts in place, and when the initial temperature conditions of the machine are such that the limits of temperature and temperature rise at the conclusion of the tests do not exceed those given in Section VII.

Excess Current and Torque Tests for Machine with Continuous Rating.

79. A machine for continuous service shall be capable of withstanding on test for fifteen seconds a load in amperes 50 per cent. in excess of its British Standard Rating, the pressure being maintained as near the rated value as possible.

An induction motor for continuous service shall be capable of withstanding on test without stalling a torque 75 per cent. in excess of the torque corresponding to its British Standard Rating, the pressure being maintained at the rated value. This test does not apply to induction motors of abnormally low speeds or high frequencies and consequently low power factor.

Starting Torque and Excess Torque Tests for Motor with Short-Time Rating.

80. A continuous current shunt wound or squirrel cage induction motor for intermittent service when running shall be capable of withstanding on test for 30 seconds a torque 100 per cent. in excess of that corresponding to its British Standard Rating, the pressure being maintained at the rated value.

A motor for intermittent service, other than a continuous current shunt wound or squirrel cage induction motor, shall be capable of exerting on test a starting torque 100 per cent. in excess of the torque corresponding to its British Standard Rating, the pressure being maintained at the rated value.

When the actual cycle of duty is specified, the tests as regards both starting and running must be such as to secure the performance with a due margin of safety.

XIV.

COMMUTATION TESTS.

Commutation Test for Continuous Current Machine.

81. A continuous current machine shall work with fixed brush setting from no load to the highest momentary load specified in Section XIII., and shall work practically sparklessly and without injury to the surface of the commutator or brushes from no load to the rated load, and without injurious sparking or injury to the commutator or brushes up to the highest momentary load specified in Section XIII.

XV.

DIELECTRIC TESTS.

Application of High Pressure Tests.

82. The high pressure tests given herewith shall be applied only to a new and completed machine in normal working condition with all its parts in place, and, unless otherwise specified, shall be carried out at the maker's works at the conclusion of the temperature test of the machine. The machine shall have been exposed to the ordinary atmosphere for at least twenty-four hours prior to the temperature test (*see* Section VIII.) and during that interval shall not be artificially baked (*see* Clause 84).

It is generally advisable that the high pressure test shall not be applied when the insulation resistance is less than that indicated in Clause 84.

Table of High Pressure Tests.

83. A high pressure test in accordance with the following table shall be applied for one minute between the windings and the frame of the machine with the core connected to the frame during the test (*see* Clauses 82 and 84 to 87).

The test pressure shall be based on the rated pressure or the highest R.M.S. pressure reached between any part of the winding and the frame, whichever is greater.

Item.	Name or Size of Machine or Part.	Test Pressure (R.M.S.)
1	Machine below 746 watts or 1 H.P.	500 volts plus twice rated pressure.
2	Machine of 746 watts or 1 H.P. and over.	1,000 volts plus twice rated pressure.
3	Machine in service.	*see* Clause 96.
4	Separately excited rotating field windings (Clause 90).	Ten times rated pressure with a maximum of 3,500 volts and with a minimum of 1,500 volts.
5	Exciter.	*see* Clause 91.
6	Wound rotor of induction motors.	*see* Clause 92.
7	Field windings of synchronous machine.	*see* Clause 93.
8	Transformers for direct connection to consumers' circuits.	*see* Clause 97.
9	Auto-starter transformer.	*see* Clause 98.

For dielectric tests for current and potential transformers, *see* British Standard Specification for Transformers for Meters and other Instruments.

Minimum Insulation Resistance.

84. The insulation resistance, in megohms, when the high pressure test is applied shall be not less than :—

$$\frac{\text{Rated pressure in volts}}{1{,}000 + \text{Rated Output in KVA.}}$$

(This formula does not apply to machines immersed in oil as the insulation resistance of the latter is in general lower than that given by the formula).

The insulation resistance shall be measured with a pressure of about 500 volts (continuous) applied for a sufficient time for the reading of the indicator to become practically steady.

Insulation resistance tests in general are of value in showing the condition of the insulation with special reference to moisture and dirt, and afford a useful indication as to whether the machine is in a suitable condition for the application of the high pressure test for dielectric strength, but insulation resistance appreciably higher than indicated above should not be specified for electrical machinery, since, in order to obtain it, long baking at high temperatures may be necessary and this may permanently damage the insulating material.

Frequency and Wave Form of Test Pressure.

85. The test pressure shall be alternating, preferably of sine wave and of any frequency between 25 and 100 periods per second.

Measurement of Test Pressure.

86. The test pressure shall be measured by means of a suitable instrument connected to the high pressure side of the transformer supplying the test pressure.

Duration of High Pressure Test.

87. The test pressure shall be applied gradually and then maintained continuously for one minute.

High-Pressure Test for Windings not Electrically Connected.

88. For a machine or apparatus with several windings which are not electrically connected a high pressure test shall be applied between each of these windings in turn and all the others connected together and to the frame and core of the machine. The test

pressure applied to each winding shall be in accordance with Clause 83, and shall be based on the rated pressure of the particular winding under test.

High Pressure Test for Windings Electrically Connected.

89. For windings connected electrically but having different rated pressures, the high pressure test shall be carried out with the windings connected, the test pressure being based on the highest rated pressure.

High Pressure Test for Separately Excited Rotating Field Windings.

90. For separately excited rotating field windings, excepting those referred to in Clause 93, the test pressure shall be 10 times the rated pressure, but not less than 1,500 volts nor more than 3,500 volts.

High Pressure Test for Exciter.

91. For an exciter the test pressure shall be not less than that applied to the field windings of the machine to which it is connected except when used with a synchronous machine intended to be started up from the alternating current side, in which case the test pressure shall be in accordance with Clause 93.

High Pressure Test for Wound Rotor of Induction Motor.

92. For a wound rotor of an induction motor the test pressure shall be in accordance with Clause 83, and shall be based on the pressure between the slip-rings on open circuit at starting.*

When an induction motor with a phase-wound rotor is intended to be reversed by reversing the primary connections while running at approximately normal speed, the test pressure shall be 1,000 volts plus four times the normal induced pressure.

In the case of a two-phase rotor, the pressure between the slip-rings referred to in these rules shall be the pressure across one phase of the rotor winding.

High Pressure Test for Field Windings of Synchronous Machine or Rotary Converter.

93. For field windings of a synchronous machine or a rotary converter, which is to be started up from the alternating current side, the test pressure shall be as follows:

(*a*) When a machine is started up with the fields closed-circuited the test pressure shall be 10 times the rated pressure

* As stated on the Rating Plate in accordance with Clause 109.

of the exciter, but not less than 1,500 volts nor more than 3,500 volts.

(*b*) When the field windings are provided with a break-up switch the test pressure shall be 5,000 volts.

When a machine is started up with the fields on open-circuit and without a break-up switch the test pressure shall be 5,000 volts for an exciter pressure of less than 250 volts, and 8,000 volts for an exciter pressure of 250 volts and above.

High Pressure Test for Machine exposed to possible Excess Pressure.

94. For a machine driven by a water-wheel and exposed to runaway conditions or for a machine exposed to possible excess pressure, pressure limiting devices should be employed, otherwise the high pressure test in accordance with Clause 83 shall be based on the highest pressure to which the windings may be subjected.

High Pressure Test for Machine for Series Connection.

95. For a machine or transformer used in series connection the test pressure shall be in accordance with Clause 83 and shall be based on the rated pressure of the system in which it is used.

NOTE.—This does not apply to a machine mounted on a special insulated stand as used in the Thury or similar system.

High Pressure Test for Machine in Service.

96. A machine which has passed its acceptance tests but has been out of service for some time, may have a high pressure test applied to it for the purpose of ensuring that the insulation is in sound working condition. Before applying the high pressure test the windings shall be cleaned and the insulation resistance measured. If the insulation resistance is below the minimum required by Clause 84 the machine shall be dried out before the application of the high pressure. The high pressure test shall be made in accordance with the requirements of this Section, except that the test pressure shall be 75 per cent. of the value specified therein.

High Pressure Test for Transformer for Consumer's Circuit.

97. For a transformer for direct connection to a consumer's circuit the test pressure between the high and low pressure windings shall be not less than 10,000 volts when the rated primary pressure is 2,000 volts or more. When the rated primary pressure is less than 2,000 volts the test pressure shall be 5,000 volts.

For the low pressure winding the test pressure shall be 1,000 volts plus twice the rated low pressure.

This Clause is intended to prevent danger from breakdown of the insulation between the windings of the transformer, but it does not afford protection against dangers arising from a leak between the high pressure and low pressure systems; for this reason it is necessary to earth the low pressure system or to provide a suitable earthing device.

High Pressure Test for Auto-Starter Transformer.

98. For an auto-starter transformer (starting compensator) the test pressure shall be the same as for the machine with which it is connected.

XVI.

SHORT-CIRCUIT TESTS.

Application of Short-Circuit Tests.

99. Short circuit tests when required shall be specified at the time of ordering the machine.

It is considered desirable to point out that in the case of a turbo-alternator which has a close inherent regulation, protective devices such as reactance coils in circuit with the machine are necessary in order to prevent damage when a short circuit occurs.

XVII.

TOLERANCES.

Compliance with Rules.

100. A machine shall be considered to have complied with these Rules when the difference between the observed results and the required results is not greater than the tolerance.

Tolerance on Rated Speed of Motor.

101. The tolerance on the rated speed of a motor above three H.P. at the temperature corresponding to rated load shall be :

For a motor with shunt characteristic ... ± 5 per cent.
For a motor with series characteristic ... $\pm 7\frac{1}{2}$ per cent.

Tolerance on Temperature Rise.

102. There is no tolerance on the limits of the observable temperature or temperature rise given in Section VII.

XVIII.

INFORMATION TO BE GIVEN ON RATING PLATE.

In the absence of any indication to the contrary on the rating plate, it shall be understood that the machine is intended for continuous service and for a cooling air temperature not exceeding 40° C. and an altitude not exceeding 3,300 feet (1,000 metres approximately) (*see* Clauses 39, 40 and 44).

General Information on Rating Plate of Machine.

103. The Rating Plate of a machine with British Standard Rating shall carry :—

(*a*) A distinctive special sign.*

(*b*) The name of the maker.

(*c*) The maker's machine number.

(*d*) The class of rating or the necessary information if the machine is intended to operate under more than one class of rating.

(*e*) The altitude if it exceeds 3,300 feet (1,000 metres approximately).

(*f*) The additional information required by the following clauses (104 to 109).

Additional Information on Rating Plate of Continuous Current Generator.

104. The Rating Plate of a continuous current generator shall state the following particulars in addition to the requirements of Clause 103 :—

Generator.

Continuous-current (C.C.)

Electrical output in KW., with a statement as to the class of rating.

Pressure between terminals, in volts, at no load and at rated output.

Current in amperes (*see* Clause 41).

Speed, in revolutions per minute.

*The question of marking British Standard Machines with the Committee's Brand is under consideration.

Additional Information on Rating Plate of Continuous Current Motor.

105. The Rating Plate of a continuous current motor shall state the following particulars in addition to the requirements of Clause 103:—

Motor.
Continuous-current (C.C.), and whether shunt, series, compound or separately excited.
Mechanical output, in H.P. and KW., with a statement as to the class of rating.
Pressure between terminals, in volts.
Current, approximate, in amperes.
Speed, in revolutions per minute, at rated output.

Additional Information on Rating Plate of Alternating Current Transformer.

106. The Rating Plate of an alternating current transformer shall state the following particulars, in addition to the requirements of Clause 103:—

Frequency, in periods per second.
Number of phases.
Electrical output at the secondary terminals, in KVA., with statement as to the class of rating.
Pressure between terminals, in volts, at no load.
Short-circuit pressure, in volts, high tension side.
Current, in amperes, low tension side (*see* Clause 41).
For three-phase transformers a vector diagram of connections in accordance with the figures and terminal markings in Sections XIX. and XX.

Additional Information on Rating Plate of Synchronous Alternator.

107. The Rating Plate of a synchronous single-phase or polyphase alternator shall state the following particulars in addition to the requirements of Clause 103:—

Alternator.
Frequency, in periods per second.
Number of phases.
Electrical output, in KVA., with statement as to the class of rating.
Pressure between terminals, in volts.
Current, in amperes (*see* Clause 41).
Power factor.
Speed, in revolutions per minute.
Excitation pressure, in volts.
Maximum exciting current, in amperes.

Additional Information on Rating Plate of Synchronous Motor.

108. The Rating Plate of a synchronous single-phase or polyphase motor shall state the following particulars in addition to the requirements of Clause 103 :—

Synchronous motor.
Frequency, in periods per second.
Number of phases.
Mechanical output, in H.P. and KW. with statement as to the class of rating.
Pressure between terminals, in volts.
Current, approximate, in amperes.
Speed, in revolutions per minute.
Excitation pressure, in volts.
Maximum exciting current, in amperes.
For a motor intended to work with a power factor different from unity, the necessary information shall be stated.

Additional Information on Rating Plate of Induction Motor.

109. The Rating Plate of an induction single-phase or polyphase motor shall state the following particulars in addition to the requirements of Clause 103 :—

Motor.
Frequency, in periods per second.
Number of phases.
Mechanical output, in H.P. and KW., with a statement as to the class of rating.
Pressure between terminals, in volts.
Current, approximate, in amperes.
Speed, in revolutions per minute, at rated output.
Pressure in volts, on open circuit between slip-rings.
Rotor current, in amperes.

XIX.

TRANSFORMER DIAGRAMS.

Classes of Transformer Diagram.

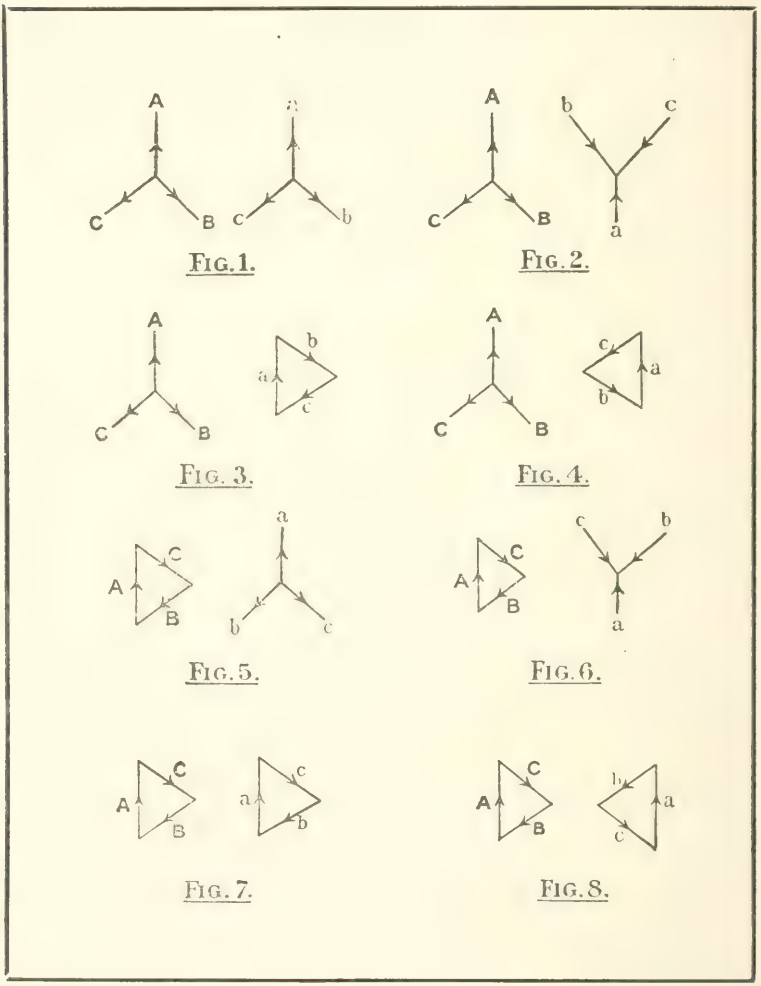
110. Two classes of diagram are recognised :—

(*a*) Vector diagram—showing the general phase relations in a three-phase transformer.

(*b*) Connection diagram—showing the relation of the various terminals to the windings.

Vector Diagram for Transformer.

111. A Vector diagram, pertaining to the high and low pressure windings, examples of which are shown in Figures 1 to 8, shall be stamped or reproduced adjacent to the respective pressures on the Rating plate.



Examples of vector diagrams which are intended to show the general phase relations in a three-phase transformer.

Vector Diagram for Three-phase Transformer.

112. In constructing the Vector diagram for a three-phase transformer, each line representing one phase of the high pressure or low pressure winding shall be marked with one phase letter (without subscript) and an arrow head to show the direction of progression (see Note to Clause 114) from terminal to terminal marked in each phase as shown in the diagrams. Each phase of the low pressure winding shall be shown parallel to the corresponding phase of the high pressure winding with their arrow heads pointing in the same direction.

Connection Diagram for Transformer.

113. The connection diagram showing the relation of the various terminals to the windings and the position of all leads and tappings shall be permanently attached to each transformer.

In these diagrams the terminals shall be marked in accordance with the requirements of Section XX.

XX.

TERMINAL MARKING FOR TRANSFORMERS.

Terminal Marking for Single-phase Transformer without Tappings.

114. The high and low pressure terminals of a single-phase transformer without tappings shall be distinguished by the letters T and t indelibly marked on the terminals. In addition to the letters, the terminals shall be distinguished by index numbers placed in such a way that the same sequence of the index numbers represents the same direction of electromotive force in both circuits at the same instant. A terminal intended to be used as a "neutral" shall be marked with N or n respectively.

Thus with only two terminals in each winding the index numbers 0 and 1 may conveniently be used in each winding so that the terminals will be marked T_0, T_1 and t_0, t_1. If in the high pressure winding the direction of electro-motive force is, at a given instant, from T_0 to T_1 or in the sequence of the lower to the higher index number, the direction of the electro-motive force generated in the low pressure winding at the same instant will also be in the sequence 0 to 1, that is from terminal t_0 to terminal t_1. To test whether the marking is in accordance with these instructions proceed as follows:—Connect the two windings in series T_1 to t_0 and apply alternating electro-motive force to the remaining free terminals T_0 and t_1. If the marking is correct the electro-motive force measured between the high pressure terminals T_0 and T_1 will be less than the applied pressure.

Terminal Marking for Single-phase Transformer with Tappings.

115. The high and low pressure terminals of a single-phase transformer with tappings shall be marked with the letters T and t respectively and with index numbers the sequence of which shall follow the same rule as in Clause 114.

Terminal Marking for Single-phase Transformer with more than one High or Low Pressure Winding.

116. When a transformer has two or more equal windings intended for series or parallel connection the terminals of each winding shall be marked in accordance with the preceding rules, but the letters of the first additional winding shall be once underlined; those of the second additional winding shall be twice underlined, and so on.

Terminal Marking for Single-phase Transformer with Separate Auxiliary Winding.

117. When an auxiliary winding is provided, discontinuous from the principal winding, the auxiliary terminals shall be marked in accordance with Clause 114 as if this winding were continuous and the letters of the auxiliary terminals shall be underlined.

Terminal Marking for a Three-phase Transformer.

118. The different phase windings of a three-phase transformer shall be distinguished by the letters A B C for the high pressure terminals and a b c for the low pressure terminals. A terminal intended to be used as a "neutral" shall be marked with N or n respectively. The letters shall be indelibly marked on the respective terminals.

In addition to these letters, the terminals shall be distinguished by index numbers in accordance with the preceding rules for single-phase transformers.

When two or more phases are connected to one terminal, as, for instance, in mesh connection, the terminal shall be marked with the corresponding phase letters and index numbers of all the leads so connected to it.

An exception to this rule is the neutral point of a star-connected winding which is only to be marked N or n.

APPENDICES.

I. Maximum Internal Temperature and Temperature Rises.

II. Embedded Temperature Detectors.

APPENDIX I.

Maximum Internal Temperatures and Temperature Rises.

The maximum output, and hence the safe limit of working of an electrical machine depends, so far as its insulation is concerned, in great measure on the maximum temperature reached by any part of the insulation and the length of time for which it is maintained at that temperature. The temperature of the machine varies from point to point, and for the purpose of ascertaining the rating of the machine it is the temperature and temperature rise of the hottest part which it would be desirable to measure. In machines as ordinarily constructed this is impossible; "observable temperatures" are therefore measured, and the temperature limits permitted are based on these. Experience shows that for each class of insulating material there is a certain maximum temperature and temperature rise which it is unsafe to exceed; the limits given for the observable temperatures and temperature rises are less than these by amounts which are considered to represent the differences likely to occur in actual machines.

The maximum temperatures to which varying classes of insulating materials may be subjected, together with the corresponding temperature rises obtained by subtracting therefrom 40° C. the maximum temperature of cooling air to which those temperature rises apply, are given in the following table:—

Class.	Description of Material.	Maximum Temperature to which the material may be subjected.	Maximum Temperature Rise.
		°C.	°C.
A.	Cotton, silk, paper and similar materials when impregnated or immersed in oil; also enamelled wire*	105	65
B.	Mica, asbestos and other materials capable of resisting high temperatures. If Class A. material is used in conjunction with Class B. material for structural purposes only, and may be destroyed without impairing the insulating or mechanical qualities of the combined material, then the material may be considered as Class B (*see* Clause 54).	125	85
C.	Fireproof and refractory materials, such as pure mica, porcelain, quartz, etc.	Limits not determined.	

* The safe temperature limit for enamelled wire depends upon the nature of the enamel employed. Until further information is available the limit given above is recommended.

For cotton, silk, paper and similar materials, when not impregnated nor immersed in oil, the maximum temperatures and

temperature rises are 10° C. below the limits fixed for Class A. materials (*see* Clause 47).

It is recognised that Class B. insulation may withstand maximum temperatures of 150° C. and even higher. However, as sufficient data covering experience over a period of years at such temperatures is at present unavailable, a conservative limit for this class of insulation has been adopted, and any increase above this figure should be the subject of special agreement.

APPENDIX II.

Embedded Temperature Detectors.

When the internal temperature of a machine is to be measured by embedded temperature detectors, a liberal number of these devices should be employed, and all reasonable efforts consistent with safety should be made to place them at the various points where the highest temperatures are likely to occur. When they are placed between two coils in one slot the temperature should not in general exceed the observable temperature by more than 5°C. and when they are placed between the insulated coil and the iron core in the case of low pressure machines (not exceeding 5,000 volts) the temperature should approximate to that of the observable temperature, and in the case of high pressure machines the temperature should not exceed the observable temperature by more than about 1°C. for each 1,000 volts or part thereof by which the rated pressure exceeds 5,000 volts.

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British Engineering Standards Association.

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OF

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OCTOBER, 1918.

(This List cancels all previous Lists.)

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26	**Locomotives for Indian Railways,** Second Report on (Superseded by No. 59).	Withdrawn.	
27	**Limit Gauges for Running Fits,** Report on Standard Systems of	1/-	1/2
28	**1908 Nuts, Bolt Heads and Spanners,** Report on	1/-	1 2
29	**1909 Steel Forgings for Marine Purposes,** Specification for Ingot	1/-	1/2
30	**1907 Steel Castings for Marine Purposes,** Specification for	1/-	1 2
31	**1910 Steel Conduits for Electrical Wiring,** Specification for	1/-	1 2
32	**1907 Steel Bars** for use in **Automatic Machines,** Specification for	1/-	1 2

Report No.		Net.	Post free.
33	**Carbon Filament Glow Lamps,** Specification for	5/-	5/2
34	**Screw Threads,** Tables of British Standard Whitworth, British Standard Fine and British Standard Pipe Threads (REVISED FEBRUARY, 1913)	Withdrawn.	
35	**Copper Alloy Bars** for use in **Automatic Machines,** Specification for	2/6	2/9
36	**Electrical Machinery,** Report on (Superseded by No. 72–1917)... ...	Withdrawn.	
37	**Electricity Meters,** Specification for (REVISED AUGUST, 1915)... ...	7/6	7/9
38–1913	**Limit Gauges for Screw Threads,** Report on Standard Systems for	1/-	1/2
39	**Screw Threads,** Combined Reports on (REVISED NOVEMBER, 1908) ...	Withdrawn.	
40–1908	**Cast Iron Low Pressure Heating Pipes,** Specification for Spigot and Socket	1/-	1/2
41–1908	**Cast Iron Flue or Smoke Pipes,** Specification for Spigot and Socket	1/-	1/2
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45–1917	**Sparking Plugs** (for Internal Combustion Engines), Report on Dimensions for	1/-	1/2
46–1909	**Keys and Keyways,** Specification for	1/-	1/2
47	**Steel Fishplates** for Bull Head and Flat Bottom Railway Rails, Specification and Sections of (REVISED DECEMBER, 1914)	10/6	10/9
48–1909	**Wrought Iron** of Smithing Quality for Shipbuilding (Grade D), Specification for	1/-	1/2
49	**Ammeters and Voltmeters,** Specification for...	5/-	5/2
50	**Locomotives for Indian Railways,** Third Report on (Superseding Nos. 5 and 26)	21/-	21/5
51	**Wrought Iron** for use in Railway Rolling Stock ("Best-Yorkshire" and Grades A, B and C), Specification for (REVISED AUGUST, 1913)	10/6	10/9
52	**Lampholders and Caps,** Specification for Bayonet Socket	Under Revision.	
53–1913	**Boiler Tubes** for Locomotive Boilers, Specification for Cold Drawn Weldless **Steel**...	1/-	1/2
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56	**Yield Point** and **Elastic Limit,** Definitions of	Gratis.	-/2
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62	**Marine Boiler Stays, Screwing** for	Gratis.	-/2
63–1913	**Broken Stone and Chippings,** Specification for Sizes of ...	1/-	1/2
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